Phytologia (December 1993) 75(6):463-480.

VASCULAR FLORA OF SANDSTONE OUTCROP COMMUNITIES IN WESTERN LOUISIANA, WITH NOTES ON RARE AND NOTEWORTHY SPECIES

M.H. MacRoberts & B.R. MacRoberts

Bog Research, 740 Columbia, Shreveport, Louisiana 71104 U.S.A.

ABSTRACT

The floristics and edaphic factors of west Louisiana sandstone outcrop communities are described. The soils of this open xeric community are moderately rich in calcium and support a number of calciphiles. Lichens and mosses are common, especially on the open rock pavement that characterizes this community. A number of rare species occur: *Talinum parviflorum*, *Schoenolirion wrightii*, *Carex meadii*, and *Selaginella arenicola* var. *riddellii*.

KEY WORDS: Sandstone outcrop, sandstone glade, calcareous prairie, cedar glade, calciphile, Kisatchie National Forest, floristics, Louisiana

INTRODUCTION

The eastern and southeastern United States is – or at least until recently was – heavily forested. Nonetheless, there were natural openings, usually of small size, scattered throughout. The more xeric of these openings – variously referred to as prairies, glades, and barrens – have long attracted the attention of naturalists, ecologists, and botanists, and there is a fairly large literature dealing with them (*e.g.*, Ebinger 1979; Perkins 1981; DeSelm 1986, 1990; Greller 1988; Baskin & Baskin 1989; Bartgis 1993).

In two previous papers, we have described sandstone glades in western Louisiana (MacRoberts & MacRoberts 1992, 1993). As our studies of open xeric communities in this area have expanded, we have become aware that there are at least two different types of sandstone related communities (MacRoberts & MacRoberts 1993). The type studied previously – referred to as glade or sandstone glade – is an open area, often mesa-like, with acidic low-nutrient soils strewn with boulders and scattered with old, slow growing, stunted trees. The sandstone community described in this paper – referred to as sandstone outcrop or simply outcrop – while superficially similar to glades, is floristically and edaphically quite distinct. Among other things, these communities have a rock pavement or ledge, not boulders, upslope from which is open calcareous prairie-like habitat. An examination of the literature suggests that these openings most resemble cedar glades of Tennessee and Kentucky, and barrens in southeastern Texas (Baskin & Baskin 1975, 1985; Marietta & Nixon 1984; Bridges & Orzell 1989; Mohlenbrock 1993).

In this paper we describe outcrop communities in the Kisatchie National Forest in western Louisiana, an area for which such communities have not yet been described. We also compare these communities with the sandstone glades that we have studied previously, and briefly discuss calcareous prairies and forests in this part of Louisiana.

STUDY SITES AND METHODS

Three outcrops were selected for detailed study. All occur within 1 km of each other in T6N R8W, about 5 km north of Kisatchie, Louisiana, in the Kisatchie Ranger District of the Kisatchie National Forest (Caldwell 1991; Martin & Smith 1991). Two of these (KG30-3 and KG30-8) have large expanses of sandstone pavement. The third (KG30-2) does not, and while underlain by sandstone bedrock, has not eroded down to it except in a few small areas. Consequently, KG30-2 represents what can be considered an earlier stage in the evolution of this community. KG30-8 is about 0.4 ha, KG30-2 about 0.6 ha, and KG30-3 about 1.2 ha. All occur at approximately 75 meters above sea level.

Following Perkins (1981) we divide outcrops into life zones (Figure 1). These are 1) eroded area below the lip of the sandstone bedrock, 2) bare rock pavement, 3) pockets of shallow soil on rock pavement, 4) sloping prairie above pavement with soils of varying depth depending on distance from exposed rock and degree of slope, and 5) tree/shrub zone uphill.

Not all outcrop communities have all zones. In the three we studied, KG30-3 and KG30-8 had all zones; KG30-2 consisted almost exclusively of zones 4 and 5, with only small areas of 2 and 3. Also, zone 1 at KG30-2 was heavily treed and shaded the very narrow zones 2 and 3. Other outcrop sites in the Kisatchie District consisted of only zones 1, 2, and 3; zones 4 and 5 had been eroded away (Figure 1). Zone 1 is perhaps the most variable, as we attempt to depict in Figure 1. Almost all of these communities are on hillsides, not on hilltops. The few we encountered on hilltops were entirely eroded to bedrock, as indicated in Figure 1.

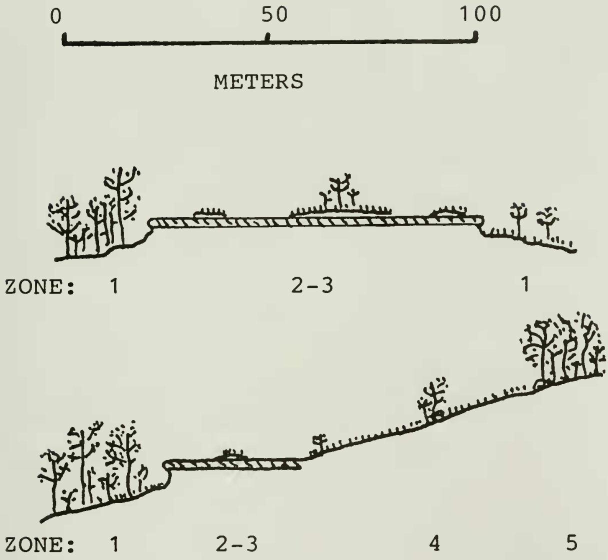

Figure 1. Profiles of typical outcrops with floristic zones indicated.

Table 1. Taxa of three sandstone outcrops.

AGAVACEAE - *Manfreda virginica* (L.) Rose.

AMARYLLIDACEAE - *Hypoxis hirsuta* (L.) Cov.

CYPERACEAE - *Carex caroliniana* Schwein., *C. flaccosperma* Dewey (2), *C. meadii* Dewey (2, 3), *Fimbristylis puberula* (Michx.) Vahl., *Rhynchospora inexpansa* (Michx.) Vahl., *R. globularis* (Chapm.) Small, *Scleria ciliata* Michx., *S. oligantha* Michx.

IRIDACEAE - *Sisyrinchium sagttiferum* Bickn. (2, 3).

JUNCACEAE - *Juncus marginatus* Rostk. (8).

LILIACEAE - *Aletris aurea* Walt., *Allium canadense* L., *Nothoscordum bivalve* (L.) Britt., *Schoenolirion wrightii* Sherman (3, 8), *Smilax* sp.

ORCHIDACEAE - *Platanthera nivea* (Nutt.) Luer (3), *Spiranthes lacera* (Raf.) Raf., *S. praecox* (Walt.) S. Wats.

POACEAE - *Agrostis elliottiana* Schultes (3, 8), *Andropogon tenarius* Michx., *Aristida longespica* Poir., *Aristida oligantha* Michx., *Aristida purpurascens* Poir. (2, 3), *Axonopus affinis* Chase (8), *Chasmanthium sessiliflorum* (Poir.) Yates (3), *Dicanthelium aciculare* (Desv. *ex* Poir.) Gould & Clark, *D. acuminatum* (Sw.) Gould & Clark (3), *D. sphaerocarpon* (Ell.) Gould, *Eragrostis elliottii* S. Wats. (8), *E. spectabilis* (Pursh) Steud. (2), *Muhlenbergia capillaris* (Lam.) Trin. (3), *Panicum anceps* Michx. (2, 8), *Paspalum notatum* Flugge (3), *Schizachyrium scoparium* (Michx.) Nash, *Schizachyrium tenerum* Nees, *Setaria geniculata* (Lam.) Beauv. (3), *Sporobolus junceus* (Michx.) Kunth (2, 3), *Vulpia octoflora* (Walt.) Rydb. (2, 3).

CUPRESSACEAE - *Juniperus virginiana* L.

PINACEAE - *Pinus echinata* P. Mill., *P. palustris* P. Mill., *P. taeda* L.

SELAGINELLACEAE - *Selaginella arenicola* Underw. var. *riddellii* (Eselt.) Waterfall (3).

ACANTHACEAE - *Ruellia humilis* Nutt.

APIACEAE - *Eryngium yuccifolium* Michx. (2).

AQUIFOLIACEAE - *Ilex decidua* Walt. (8), *I. vomitoria* Ait.

ASCLEPIADACEAE - *Asclepias longifolia* Michx., *A. viridiflora* Raf. (2, 3).

Table 1 (continued).

ASTERACEAE - *Aster dumosus* L., *A. linariifolius* L., *A. oolentangiensis* Ridd. (3), *A. paludosus* Dryand. *ex* Ait. ssp. *hemisphericus* (Alex.) Cronq., *A. patens* Ait. (2, 3), *A. sericeus* Vent., *Bigelowia nuttallii* Anderson, *Cirsium carolinianum* (Walt.) Fern. & Schub. (2, 3), *Coreopsis lanceolata* L., *Erigeron strigosus* Muhl. *ex* Willd. (2, 3), *Gnaphalium purpureum* L. (2, 3), *Helianthus angustifolius* L., *Heterotheca graminifolia* (Michx.) Shinners, *Krigia virginica* (L.) Willd. (3, 8), *Liatris aspera* Michx. (2), *L. earlei* (E. Greene) Schum. (2), *L. squarrosa* (L.) Michx., *Pyrrhopappus carolinianus* (Walt.) DC. (2), *Silphium laciniatum* L., *Solidago nitida* Torr. & Gray (2, 3), *Vernonia texana* (A. Gray) Small (2).

BIGNONIACEAE - *Campsis radicans* (L.) Seem. *ex* Bureau (3).

CAMPANULACEAE - *Lobelia appendiculata* A.DC., *Triodanis perfoliata* (L.) Nieuwl. (2).

CISTACEAE - *Lechea tenuifolia* Michx. (3).

CLUSIACEAE - *Hypericum gentianoides* (L.) B.S.P. (3, 8), *H. hypericoides* (L.) Crantz.

CONVOLVULACEAE - *Evolvulus sericeus* Sw.

CORNACEAE - *Cornus florida* L. (3).

DROSERACEAE - *Drosera brevifolia* Pursh (8).

ERICACEAE - *Vaccinium arboreum* Marsh., *V. corymbosum* L. (3, 8).

EUPHORBIACEAE - *Croton capitatus* Michx. (2), *Crotonopsis elliptica* Willd., *Euphorbia corollata* L., *Tragia urticifolia* Michx. (3).

FABACEAE - *Baptisia leucophaea* Nutt., *Crotalaria sagittalis* L. (2), *Dalea candida* (Michx.) Willd. (3), *D. purpurea* Vent. (3), *Galactia volubilis* (L.) Britt. (2, 3), *Medicago lupulina* L. (2), *Schrankia microphylla* (Dry.) J.F. Macbr. (2, 8), *Stylosanthes biflora* (L.) B.S.P., *Tephrosia virginiana* (L.) Pers.

FAGACEAE - *Quercus falcata* Michx. (2), *Q. marilandica* Muenchh., *Q. stellata* Wang.

GENTIANACEAE - *Sabatia campestris* Nutt.

HAMAMELIDACEAE - *Liquidambar styraciflua* L.

Table 1 (continued).

JUGLANDACEAE - *Carya* sp. (3).

LAMIACEAE - *Hedeoma hispidum* Pursh (2, 3), *Prunella vulgaris* L., *Salvia lyrata* L., *Scutellaria integrifolia* L. (2, 8), *Scutellaria parvula* Michx. (3).

LENTIBULARIACEAE - *Pinguicula pumila* Michx. (8).

LINACEAE - *Linum medium* (Planch.) Britt.

LOGANIACEAE - *Gelsemium sempervirens* (L.) St. Hil.

MYRICACEAE - *Myrica cerifera* L.

ONAGRACEAE - *Gaura* sp. (2), *Oenothera linifolia* Nutt. (3, 8).

OXALIDACEAE - *Oxalis stricta* L.

PLANTAGINACEAE - *Plantago aristata* Michx. (3), *P. virginica* L. (2, 3).

POLEMONIACEAE - *Phlox pilosa* L.

POLYGALACEAE - *Polygala nana* (Michx.) DC., *P. verticillata* L. (2, 3).

PORTULACACEAE - *Talinum parviflorum* Nutt. *ex* Torr. & Gray (3, 8).

RANUNCULACEAE - *Delphinium carolinianum* Walt. (3).

RHAMNACEAE - *Berchemia scandens* (Hill) K. Koch.

ROSACEAE - *Crataegus marshallii* Eggleston, *C. spathulata* Michx., *Prunus* sp. (3), *Rubus* sp. (2).

RUBIACEAE - *Diodia teres* Walt., *Hedyotis crassifolia* Raf., *H. nigricans* (Lam.) Fosberg (2, 3).

SCROPHULARIACEAE - *Agalinis fasciculata* (Ell.) Raf. (8), *Agalinis plukenettii* (Ell.) Raf. (3, 8), *Agalinis skinneriana* (Wood.) Britt. (2, 3), *Aureolaria pectinata* (Nutt.) Penn. (2, 3).

VERBENACEAE - *Callicarpa americana* L. (2), *Verbena halei* Small (2).

VIOLACEAE - *Viola pedata* L.

Table 1 is a list of the vascular plants found in zones 2, 3, and 4 of KG30-2, 3, and 8. The number "2" following the species indicates presence at KG30-2, "3" presence at KG30-3, and "8" presence at KG30-8. Absence of a letter indicates presence at all three sites.

We recorded a total of 136 taxa, representing 102 genera and 48 families for the three outcrops. KG30-3 had 110 species and 84 genera, KG30-2 had 101 species and 78 genera, and KG30-8 had 82 species and 65 genera, which makes these communities as rich in species as bogs (MacRoberts & MacRoberts 1992). Plant families with the greatest representation are Asteraceae, Fabaceae, and Poaceae, which account for 37% of the total. However, lichens and mosses, important components of the outcrop communities especially in zones 2 and 3, are not included here.

The three outcrops are similar. Among them, Sorensen's Index of Similarity ranges from 74 to 78. Combining all plants from sandstone glades (MacRoberts & MacRoberts 1992, 1993) and from sandstone outcrops, and comparing these lists, shows that glades and outcrops are not the same community. Sorensen's Index of Similarity between them is 49.

We visited all three study sites every two weeks from March to mid-November 1993 to collect and identify plants. Although these communities are rich in lichens and mosses, we did not attempt to identify them. We follow MacRoberts (1984, 1989), Gandhi & Thomas (1989), and Allen (1992) in most instances for botanical nomenclature. Voucher specimens of many of the species collected are deposited in the Vanderbilt University Herbarium (VDB). While the specific fire history of outcrop communities is uncertain, they are embedded in the pyrogenic longleaf pine community and thus probably burned with regularity in the past (Martin & Smith 1991; Smith 1991). The study sites had not burned in several years. Soil samples were taken from all zones at each study site and from all zones of a number of other outcrop communities from several calcareous prairies, and from one calcareous forest. The samples were analyzed by A & L Analytical Laboratories, Memphis, Tennessee.

To compare the spatial distribution and size of trees in outcrops with those in other communities, we ran transects through the middle of KG30-2, 3, and 8. This totaled an area 195 meters long and 3 meters wide (585 square meters). Within this area we mapped all trees over 1.5 meters tall and measured their diameter at breast height (dbh).

We cut at ground level four small pines (3 loblolly and 1 shortleaf) from zone 4 of KG30-3 to examine growth rings and thus growth rate.

We randomly selected ten temporary one meter square plots each in KG30-2, 3, and 8. Ten plots were in the thin soils on the pavement area (zone 3) and twenty in the deeper soils upslope (zone 4). In each we counted pine seedlings (first and second year trees) to see if pine establishment differed between glades and outcrops, and to determine why these communities remain open (see MacRoberts & MacRoberts 1993).

Using aerial photographs, we located 33 additional outcrop communities and surveyed each of these at least once, noting extent of sandstone pavement, erosion, flora, condition, typical and rare species, size, and other features. These surveys extended from February 1992 until December 1993.

Climatic data are given in Martin *et al.* (1990). Annual precipitation averages about 125 cm and is fairly evenly distributed throughout the year. In summer, temperatures rise to 35° C, which, combined with short droughts, translates into very hot and dry conditions, especially in open areas.

RESULTS

No vascular plant grew entirely on bare rock (zone 2); these areas were either bare or lichen covered. Lichens, mosses, and vascular plants occurred in zone 3. Depending on soil depth, there might also be a few very stunted pines or oaks. Lichens and mosses were found almost entirely in zones 2 and 3, and in the shallow soils between 3 and 4. When soil depth increased, lichens dropped out and were replaced by forbs and grasses, and by an occasional shrub. The few trees and shrubs growing in zone 4 usually occurred in scattered clumps. Zone 5 typically began abruptly as dense woods with heavy mid- and understory.

Table 2 gives soil characteristics of the various zones. We collected soil samples from nine outcrops. These represent all zones, but especially 3 and 4, notably near rare species such as *Schoenolirion* and *Talinum* (both occur in zone 3). In Table 2 we have combined and averaged also, soils from several outcrops. Soils for zone 4 are divided into two groups: 4a is the upper 15 cm; 4b is 0.5 m deep or deeper. The upper layer of zone 4 is dark grey to black, but changes to light grey or buff between 0.25 and 0.5 m.

It was abundantly clear prior to soil analysis that the vegetation in the outcrop openings was usually calciphilous, and that almost always in the immediate vicinity of outcrops there was calcareous forest and very occasionally remnant calcareous prairie. Species characterizing calcareous forest and prairie are *Aesculus pavia* L., *Andropogon* spp., *Apocynum cannabinum* L., *Aristida* spp., *Berchemia scandens*, *Bumelia lycioides* (L.) Pers., *Crataegus* spp., *Dalea* spp., *Gleditsia triacanthos* L., *Helianthus hirsutus* Raf., *Juniperus virginiana*, *Neptunia lutea* (Leavenw.) Benth., *Prunus* spp., *Ratibida pinnata* (Vent.) Barnhart, *Salvia azurea* Lam., *Schizachyrium* spp., *Schrankia microphylla* (Sm.) Macbr., and *Viburnum dentatum* L.

To have a standard by which to judge their soil properties and those of associated communities, we collected and analyzed soils from two well studied calcareous prairies (Carpenter Road Prairie and Coldwater Road Prairie, Smith *et al.* 1989) in the Winn Ranger District of the Kisatchie National Forest about 65 km northeast of our study sites. We also had soils analyzed from

Table 2. Soil characteristics.

		Exchangeable ions (ppm)				
Sample	pH	P	K	Ca	Mg	OM%
All Outcrops (Kisatchie District)						
Zone 1 (3)	5.5	5	91	2223	285	1.0
Zone 3 (15)	5.3	15	83	1193	250	1.6
Zone 4a (11)	5.4	6	102	2535	281	3.2
Zone 4b (2)	7.8	1	117	4780	346	1.0
Zone 5 (2)	5.3	14	134	3590	376	9.1
Specific Outcrops (Kisatchie District)						
KG30-2						
Zone 4 (2)	5.4	4	198	4290	459	3.8
KG30-3						
Zone 4 (1)	5.9	3	151	3910	326	3.3
Zone 5 (2)	5.3	14	134	3590	376	9.1
KG30-8						
Zone 4 (1)	4.8	7	87	720	272	2.3
Prairies (Winn District)						
Carpenter (3)	7.8	3	137	3667	51	7.4
Coldwater (2)	7.7	1	183	5145	73	7.0
Prairies (Kisatchie District)						
Ratibida (3)	7.7	3	182	7330	90	6.7
K50H (2)	7.8	1	174	6485	60	4.6
Calcareous Forest (Kisatchie District)						
K50C (1)	5.9	3	234	6530	308	8.7

Table 3. Tree species number and size on outcrops.

Species	No. on outcrops	Average dbh (cm)	(range)
Pinus palustris	7	14.9	(5.1-22.9)
P. taeda	12	6.2	(2.5-12.7)
P. echinata	2	17.1	(3.8-30.5)
Quercus marilandica	3	4.2	(2.5-7.6)

Table 4. Tree size.

Diameter class dbh (cm)	No. of trees
1-5	9
5-10	5
10-15	4
15-20	2
20-25	3
25-30	0
30-35	1

two calcareous prairie remnants (Ratibida Prairie and K50H Prairie) and one calcareous forest located near outcrops on the Kisatchie Ranger District. The number of samples collected and analyzed from each area, zone, and site is shown in parentheses in the table. The average is given where there is more than one sample.

The area in which we located outcrops during our survey is a band several miles wide that runs east-west across the entire Kisatchie District (a distance of about 30 km). This band appears to correspond with the Lena Member of the Fleming Formation, the chief characteristic of which is its "calcareous clays" (Gorat & Roland 1984).

It was not surprising therefore to find that the soil samples confirmed what the vegetation already told us. The soils were calcareous. In some places, we found narrow strata consisting of nothing but calcareous concretions frequently there were small calcium aggregations scattered on the surface and mixed throughout the soils. This admixture may account for the low pH and high calcium in the samples.

The Natchitoches Parish soil survey classifies the areas in which the outcrops occur as Kisatchie soils; that is, "fine, montmorillonitic, thermic Typic Hapludalfs" (Martin *et al.* 1990). With the exception of high calcium, they are identical in acidity and mineral contents to the soils of the sandstone glades we studied earlier (MacRoberts & MacRoberts 1992, 1993).

As the data in the table show, the soils in KG30-2 and KG30-3 are as calcareous as the soils in the calcareous prairies. While some differences exist between the outcrop soils and those described from the prairies, notably surface pH and magnesium, the calcium content is approximately the same.

Tables 3 and 4 give information on tree distribution in transects in outcrop communities.

A comparison of the data given in our previous papers (MacRoberts & MacRoberts 1990, 1993) shows that outcrops and glades are very similar in the distribution and abundance of trees, and that they differ in a number of ways from bogs and pinewoods. In pinewoods there was one tree per 11 square m, in glades there was one tree per 23.5 square m, and in bogs one tree per 35 square m. We found that in outcrops there was one tree per 24 square m. In bogs, glades, and outcrops the trees are stunted and old growth. However, bogs lack oaks, which are common in both glades and outcrops. In outcrops, trees are almost entirely confined to zones 1, 4, and 5. Zones 2 and 3 lack sufficient soil for trees to survive.

In our previous study, we found that the growth rate of pines differed significantly among glades, bogs, and pinewoods. Trees in glades grew at the slowest rate, averaging 11.5 rings per cm; bogs came next with 8.6 rings per cm; and trees in upland pinewoods had 3.7 rings per cm. The growth rate of pines from KG30-3 zone 4 was intermediate between bogs and glades, with 10.75 rings per cm (the four trees had 11, 11, 11, and 10 rings per cm). While this sample is small, it is unlikely that a larger sample would significantly alter the results since the trees in outcrops – as in bogs and glades – are clearly under stress (stunted, gnarled, and with scanty foliage).

In the outcrop communities, pine seedlings were absent in zone 2 and scarce in zone 3. In the ten one m square plots we examined in zone 3, there were only two seedlings. In the 20 plots from zone 4, there were 13 seedlings. In glades, pine seedlings fared better: 50 plots had 169 seedlings (MacRoberts & MacRoberts 1993). But the end result is the same in these two habitats. Irrespective of the number of pines that sprout and survive for a year or two, the vast majority eventually die. By the end of summer, after a few July and August droughts, very few pine seedlings remain.

Why do outcrop communities remain open? Several factors seem important (MacRoberts & MacRoberts 1990, 1993). First, edaphic conditions may be unfavorable. The soil itself appears to be nonabsorbant.. We have excavated post holes in outcrops after two days of rain only to find that the soil is dry 10-15 cm below the surface. Also in outcrops, as in glades, there is an impermeable layer of rock. Further, even where soils are deep, the soil characteristics themselves impede woody plant establishment. The soil is high in calcium, which is known to deter growth in many plants including pines, and is stiff and seasonally droughty with high shrink-swell properties (Martin & Smith 1991: 64). Open areas are subject to very high summer temperatures and short droughts put severe stress on pine seedlings. But the fact that trees and midstory vegetation begin abruptly in zone 5 would indicate that there is something different between the soils in zones 4 and 5. The soil samples did not reveal what that might be.

During the course of this study we surveyed 36 outcrop communities in the Kisatchie District. These ranged in size from 0.1-2.0 ha (average 0.8 ha). Most contained all zones, but several consisted entirely or almost entirely of zone 4 (*i.e.*, were prairie-like) but were on slopes, not hilltops. That we were dealing

Table 5. Statistics on *Schoenolirion wrightii* populations.

Outcrop	Size (ha)	No. plants	Plant coverage (ha)	Cattle grazing
KG30-3	1.2	250	0.01	yes
KG30-5	1.2	150	0.01	yes
KG30-8	0.4	75	0.005	yes
KG36-1	0.4	1000	0.2	no
Sheard I	1.2	450	0.3	no

with an outcrop community at such sites was usually evident by the flora and also by the presence, discovered with minimal searching, of a rock ledge down slope, hidden by shrubby vegetation, that had not eroded out to pavement dimensions. Since all of these outcrops occurred at approximately 75 m above sea level, and since the rock layer was similar throughout, we assume that the same geological strata are repeated wherever outcrops occur.

NOTEWORTHY SPECIES

During the course of this study we found a number of species that deserve additional comment.

Schoenolirion wrightii. (*MacRoberts & MacRoberts 1901* [VDB]). This species is globally, federally, and state listed as rare (G3, C2, S1 Louisiana, S2 Texas) (see Nixon & Ward 1981; Orzell 1990; Grace 1993; for literature and recent reviews).

Between April 17, 1993, when we first discovered *Schoenolirion wrightii* on the Kisatchie National Forest and May 7, 1993, when it had ceased blooming and was becoming difficult to locate, we surveyed 19 outcrops in the western part of the Kisatchie Ranger District and found it at five sites (26%), often in large numbers (Table 5). The five populations are all located in T6N R8W a few miles north of Kisatchie, Louisiana. Within this area, the closest two populations are about 1 km apart; the most distant are 5 km apart.

In three outcrops *Schoenolirion wrightii* was confined to a small area. In the other two, it was much more widespread. In these latter two sites, cattle had been excluded for several years. In one of the outcrops where grazing occurred, the small population of *S. wrightii* was entirely grazed down just after it had set seed.

In an outcrop bisected by a road, a recent non-growing season prescribed burn (February 13, 1993) had burned the southern half. Although *Schoeno-*

lirion wrightii bloomed and set seed in both burned and unburned portions, plants appeared to be more prolific and larger in the unburned area.

We examined soils in the five outcrops in which *Schoenolirion wrightii* occurred. These soils are the same as those reported for zone 3 in Table 2 and can be as shallow as a few inches only.

Carex meadii. (*MacRoberts & MacRoberts 1889* [VDB]). Prior to the present study, this western species had been reported only once from Louisiana (Williams 1977; MacRoberts 1989), and specimens from three other parishes have recently been found in herbaria (Julia Larke, pers. comm.). It is currently ranked as rare (S1) in Louisiana. Although we made no special attempt to search for this species, we located three outcrops where it occurred in zone 4. Two of these are within 1 km of each other; the other is about 6 km distant.

Selaginella arenicola ssp. *riddellii.* (*MacRoberts & MacRoberts 1809* [VDB]). Riddell's spikemoss is rare (S1) in Louisiana. It occurs in zone 3 and is often associated with moss or lichens. We surveyed 36 outcrops in the Kisatchie Ranger District and found it, often in large mats, in five. The plants are easily dislodged by cattle trampling.

Talinum parviflorum. (*MacRoberts & MacRoberts 1759, 1780* [VDB]). This plant is rare in Louisiana (S1). At the beginning of this study, it was only known from three closely adjacent outcrops on the Kisatchie Ranger District. We found it in 24 of the 36 outcrops we surveyed, often in large numbers (more than 1000 plants). It grows almost exclusively in thin soils in slight depressions on the rock pavements in full sun (zone 3). It blooms in late afternoon. We collected soils in which *Talinum* grew from eight outcrops. All appear to be soils typical of zone 3.

Habranthus tubispathus (L'Herit.) Traub. (*MacRoberts & MacRoberts 2093* [VDB]). While not considered rare, we found this West Gulf Coastal Plain endemic at one outcrop, where it was abundant. It did not occur at KG30-2, 3, or 8.

It is found in barrens/glade/prairie habitat in southeast Texas (Orzell 1990).

DISCUSSION

During the course of this work, it became evident that we were sealing with a community that consisted of a sandstone outcrop and upslope a calcareous opening that would best fit the definition of prairie. But we have chosen not to call these upslope openings prairies after examining "true" calcareous prairies, which appear to be floristically somewhat different, are located on hilltops, not side slopes, and which are alkaline and usually more calcareous. Nonetheless, the upslope openings (zone 4) should be looked at as a type of calcareous prairie since their soils are calcareous and their flora is calciphilous.

The outcrop communities occurring in the Kisatchie National Forest appear to be very similar to the open ("prairie-like" or "barrens") communities described by Marietta & Nixon (1984), Bridges & Orzell (1989), Orzell (1990), and Mohlenbrock (1993) for east Texas. They are similar also to a number of barrens, glades, and prairies described for Arkansas and Missouri eastward. Notably similar appear to be the various cedar glades of Tennessee and Kentucky (Baskin & Baskin 1975, 1985, 1989; DeSelm 1986) and the "Black Belt" flora of Alabama (Robert Kral, pers. comm.).

We did not divide out floristic surveys according to zones. But clearly if we had done so, the different zones would have shown significant differences. Many plants that grow on the thin soils overlaying rock outcrops do not grow in the upslope zones, and vice versa. For example, *Talinum* and *Selaginella* are found only on or near rock pavements (zone 3); whereas the many composites, peas, and grasses typically occur in zone 4. It should be remembered, however, that what does grow on these outcrops is in part determined by the soils that erode down onto them from above and that, in the present case, these are usually calcareous. Since we have not had the opportunity to study outcrops with other soils upslope, we are not in a position to say how different they might be.

KG30-2, 3, and 8 were grazed. While this was not an ideal condition under which to make a floristic study, it did provide us with information on the effect of cattle on these communities. In a word, cattle have a disastrous effect. Not only do they crop the plants (they ate all the newly seeded *Schoenolirion wrightii* from one outcrop), but they crush and dislodge lichens and other plants, especially in zones 2 and 3. Trampling also initiates erosion in zones 1 and 4, where soils are so unstable (Martin *et al.* 1990) that massive erosion results, which not only sweeps away the soil above the rock shelf, but undermines the rock itself. The devastation caused by cattle shows that these communities require a good stable ground cover to keep them intact. Many of the outcrops on the Kisatchie National Forest that were once grazed are now free of cattle, and we are happy to report that the Forest Service has fenced the outcrops where this study took place.

One thing that did surprise us was that, although the three outcrops were grazed, we found no noticable difference in our floristic lists between them and outcrops that had not been grazed for some years. The only difference was that grasses in grazed areas were difficult to find and in short supply. Undoubtedly, a study using plots would reveal many differences in composition and number of species present between grazed and ungrazed sites.

Our work on open xeric rocky communities in the Kisatchie National Forest has convinced us that there are at least two distinct types (MacRoberts & MacRoberts 1993). This year's field work establishes that sandstone outcrops are clearly distinct from sandstone glades.

This finding clarifies some confusion that currently exists in the Louisiana botanical literature. The community initially described by Smith (1988) was a sandstone outcrop, but when Martin & Smith (1991) described the major community types of the Kisatchie District of the Kisatchie National Forest, they reiterated Smith's 1988 description of the outcrop community, but exemplified it with a glade community. Hart & Lester (1993), without additional research or reference to the growing literature, have perpetuated the confusion by synonymizing glade and outcrop. Future community classifications should distinguish between sandstone outcrops and sandstone glades.

ACKNOWLEDGMENTS

The continuing cooperation and assistance of the staff of the Kisatchie National Forest have been instrumental in making this study, as in all our botanical research, possible. Especially to be thanked are Tom Fair, Susan Carr, and Viola Ritchie. Allan Tiarks, Southern Forest Experiment Station, answered some questions we had about the soil data. Financial support was provided, in part, by a Challenge Cost-Share Agreement with the Kisatchie National Forest. Robert Kral vetted a number of the plants, notably our *Carex* specimens. Julia Larke, Louisiana Natural Heritage Program, provided information on *Carex meadii* and other rare plant species. Jerry Baskin and Robert Kral made helpful comments on the paper.

LITERATURE CITED

Allen, C.A. 1992. *Grasses of Louisiana.* Cajun Prairie Habitat Preservation Society, Eunice, Louisiana.

Bartgis, R.L. 1993. The limestone glades and barrens of West Virginia. Castanea 58:69-89.

Baskin, C.C. & J.M. Baskin. 1975. The cedar glade flora of Bullitt County, Kentucky. Castanea 40:184-190.

Baskin, J.M. & C.C. Baskin. 1985. A floristic study of a cedar glade in Blue Licks Battlefield State Park, Kentucky. Castanea 50:19-25.

Baskin, J.M. & C.C. Baskin. 1989. Cedar glade endemics in Tennessee, and a review of autecology. J. Tenn. Acad. Sci. 64:63-74.

Bridges, E.L. & S.L. Orzell. 1989. Longleaf pine communities of the West Gulf Coastal plain. Natural Areas Journal 9:246-263.

Caldwell, J. 1991. Kisatchie National Forest: Part of a 100-year heritage. Forests & People 41(1):35-46.

DeSelm, H.R. 1986. Natural forest openings on uplands of the eastern United States. Pp. 366-375. *In* D.L. Kulhavy & R.N. Conner (eds.), *Wilderness and Natural Areas in the Eastern United States: A Management Challenge.* Center for Applied Studies, School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.

DeSelm, H.R. 1990. Flora and vegetation of some barrens of the eastern highland rim of Tennessee. Castanea 55:186-206.

Ebinger, J.E. 1979. Vascular flora of sandstone outcrops in Clark County, Illinois. Castanea 44:38-44.

Gandhi, K.N. & R.D. Thomas. 1989. *Asteraceae of Louisiana.* Sida Bot. Misc., No. 4:1-202.

Grace, S.L. 1993. Element stewardship abstract: *Schoenolirion wrightii.* Unpublished report, The Nature Conservancy of Texas, Silsbee, Texas.

Greller, A.M. 1988. Deciduous forest. Pp. 287-316 *In* M.G. Barbour & W.D. Billings (eds.). *North American Terrestrial Vegetation.* Cambridge University Press, New York, New York.

Groat, C.G. & H.L. Roland. 1984. Louisiana Geological Survey, Geologic Map of Louisiana. Louisiana Department of Natural Resources, Baton Rouge, Louisiana.

Hart, B.L. & G.D. Lester. 1993. Natural community and sensitive species assessment on Fort Polk Military Reservation, Louisiana. Louisiana Department of Wildlife and Fisheries, Baton Rouge, Louisiana. Unpublished report.

MacRoberts, D.T. 1984. *The Vascular Plants of Louisiana.* Bull. Museum of Life Sciences, Louisiana State University, Shreveport, Louisiana.

MacRoberts, D.T. 1989. *A Documented Checklist and Atlas of the Vascular Flora of Louisiana.* Bull. Museum of Life Sciences, Louisiana State University, Shreveport, Louisiana.

MacRoberts, B.R. & M.H. MacRoberts. 1992. Floristics of four small bogs in western Louisiana with observations on species/area relationships. Phytologia 73:49-56.

MacRoberts, M.H. & B.R. MacRoberts. 1990. Size distribution of trees in bogs and pine woodlands in west central Louisiana. Phytologia 68:428-434.

MacRoberts, M.H. & B.R. MacRoberts. 1992. Floristics of a sandstone glade in western Louisiana. Phytologia 72:130-138.

MacRoberts, M.H. & B.R. MacRoberts. 1993a. Why don't west Louisiana bogs and glades grow up into forests? Phytologia 74:26-34.

MacRoberts, M.H. & B.R. MacRoberts. 1993b. Floristics of two Louisiana sandstone glades. Phytologia 74:431-437.

Marietta, K.L. & E.S. Nixon. 1984. Vegetation of an open, prairie-like community in eastern Texas. Texas J. Sci. 36:25-32.

Martin, D.L. & L.M. Smith. 1991. A survey and description of the natural plant communities of the Kisatchie National Forest: Winn and Kisatchie Districts. Unpublished report. Louisiana Department of Wildlife and Fisheries, Baton Rouge, Louisiana.

Martin, P.G., C.L. Butler, E. Scott, J.E. Lyles, M. Mariano, J. Ragus, P. Mason, & L. Schoelerman. 1990. Soil Survey of Natchitoches Parish, Louisiana. United States Department of Agriculture, Soil Conservation Service. Baton Rouge, Louisiana.

Mohlenbrock, R.H. 1993. Black Branch Barrens, Texas. Natural History (March):30-32.

Nixon, E.S. & J.R. Ward. 1981. Distribution of *Schoenolirion wrightii* (Liliaceae) and *Bartonia texana* (Gentianaceae). Sida 9:64-69.

Orzell, S.L. 1990. Texas Natural Heritage Program Inventory of National Forests and National Grasslands in Texas. Unpublished report. Texas Parks and Wildlife Department, Austin, Texas, and U.S. Forest Service, Lufkin, Texas.

Perkins, B.E. 1981. Vegetation of sandstone outcrops of the Cumberland plateau. M.S. thesis. University of Tennessee, Knoxville, Tennessee. 140 pp.

Smith, L.M. 1988. The natural communities of Louisiana. Louisiana Natural Heritage Program, Baton Rouge, Louisiana. Unpublished report.

Smith, L.M. 1991. Louisiana longleaf: An endangered legacy. Louisiana Conservationist (May/June):24-27.

Smith, L.M., N.M. Gilmore, R.P. Martin, & G.D. Lester. 1989. Keiffer calcareous prairie/forest complex: A research report and preliminary management plan. Unpublished report. Louisiana Department of Wildlife and Fisheries, Baton Rouge, Louisiana.

Williams, J.R. 1977. Food plants of seven selected monocot families for Louisiana wildlife. M.S. thesis, Louisiana Tech University, Ruston, Louisiana.